Space Weather Technical Forecast

Issued on Saturday, 24 December 2022 at 01:17 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance G1/Minor Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with several C-class flares, peaking C6.6 at 23/1446 UTC from AR3171 Cao/Beta. There are five sunspot regions on the disc, with the main feature being a series of sunspots, comprising of AR3171 and AR3169 Cso/Beta, in the north centre disc. This complex of spots includes three mature positive spots which have exhibited some decline, but also have a central area of small developing negative spots with ongoing flux emergence. The other three regions are small and simpler. No Earth-directed CMEs have been observed. A filament eruption was observed off the southwest, however this is missing ahead of Earth. A further disappearing solar filament (DSF) has occurred in the southern central disc, near ex-AR3170, and further imagery is required to see if a CME has been produced.

Solar Wind / Geomagnetic Activity: Elevated solar winds became enhanced further due to a transition into the fast winds of CH56/+. Speeds of 450-550 km/s were observed at L1 by DSCOVR and ACE for much of the period before increasing to 550-600km/s after 23/2000 UTC. The density was around average. The total IMF, Bt, was Moderate at 8-10 nT, with the north-south component, Bz, varying between -10 nT and +7nT. The phi angle was mostly positive (away from the Sun). Geomagnetic activity was Quiet to Active (Kp 2-4) with two G1/Minor Storm intervals (Kp 5) at 23/1200-1500 UTC and 23/2100-0000 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2 MeV), as observed by GOES16, was at mostly Background levels. The associated 24-hour fluence continued below Active (1e8 integrated pfu). Observed fluence at 24/0000 UTC was 2.0e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to remain Low, with occasional C-class flares likely. There remains a slight chance of M-flares throughout the forecast period.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs, however a weak and narrow CME that is expected to pass behind the Earth may give a glancing impact on day 1 (24th). Solar winds are forecast to be slightly elevated or elevated through the period due to ongoing fast winds, with a further enhancement likely from CH57/+ day 3 or day 4 (26th or 27th). Quiet to Active geomagnetic activity is expected at first day 1 (24th), with a chance of G1/Minor Storm intervals, and later if any glance occurs from the passing CME. Otherwise easing by day 2 (25th) to Quiet with Unsettled spells and isolated Active intervals. Although an ongoing chance of further G1/Minor storms, greatest day 3 (26th).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout. High energy (greater than 2 MeV) electron flux is expected to rise due to recent and expected fast wind enhancements, perhaps reaching High levels on diurnal peaks, especially by the end of the period. The associated 24 hour electron fluence is likely to be below the Active (1e8 integrated pfu) threshold, but with a rising

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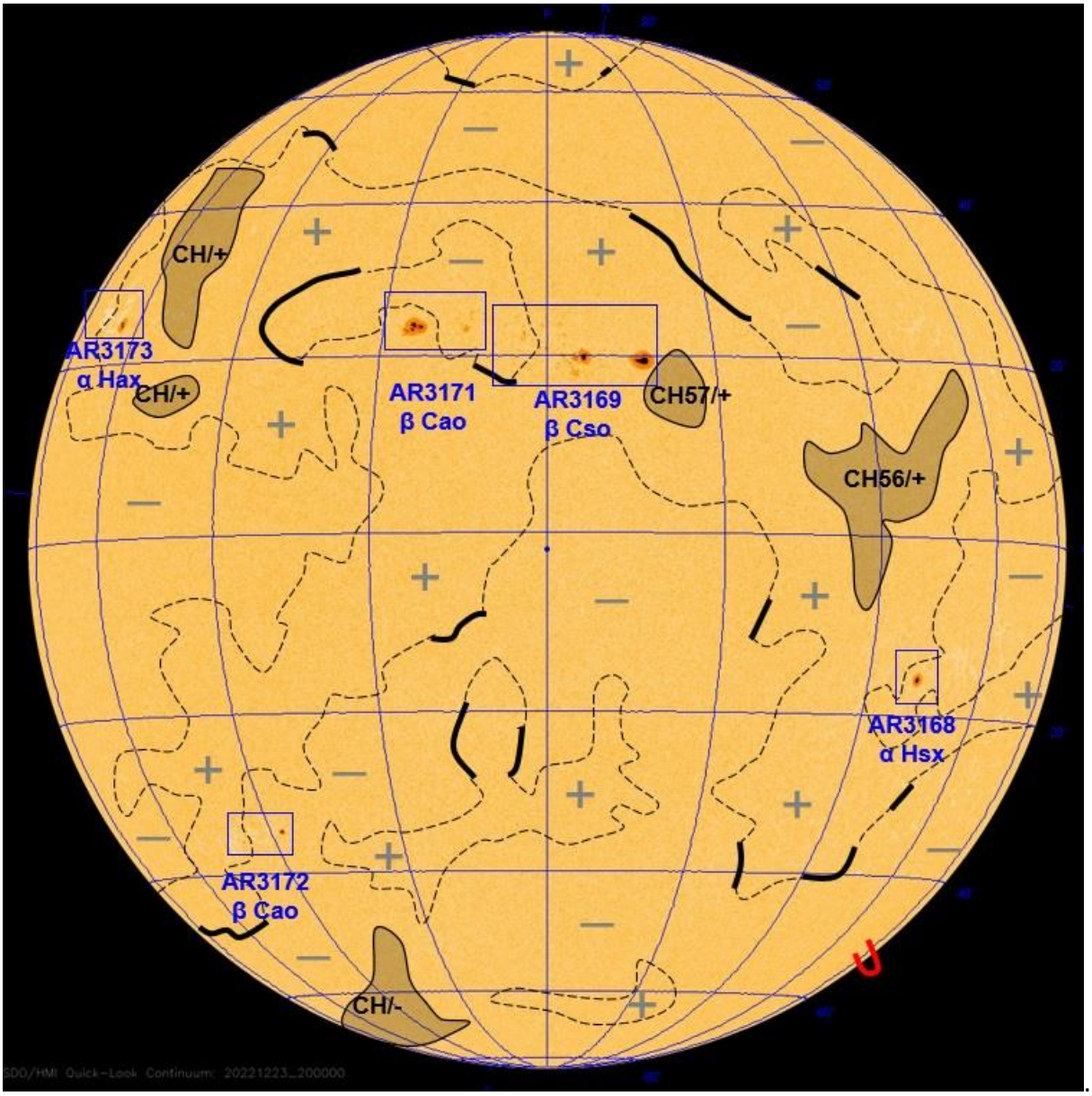
trend, giving a chance of rising above the threshold by day 3 or day 4 (26th or 27th).

Figure 1. Solar Analysis Valid 23/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs, although a slight glance cannot be completely ruled out from a narrow CME which left the Sun on the 21st passing behind the Earth on the 24th.

Earth is currently embedded within the fast wind, likely recently transitioning from the HSS from CH55/+ to the HSS from CH56/+. Ongoing slightly elevated to elevated winds are expected to only gradually ease later day 1 and day 2 (24th and 25th), with a further weak re-enhancement possible day 3 or 4 (26th or 27th) from the arrival of any fast winds from CH57/+, as shown by enlil model winds. This feature is much reduced compared to the previous rotation, so while persistence is currently verifying well to conditions, this is likely to become poor through day 2 (25th) with the indicated enhancement both too early and too strong.

Quiet to Active geomagnetic activity at first day 1 (24th), with a chance of G1/Minor Storm intervals, and later if any glance occurs from the passing CME. Otherwise easing by day 2 (25th) to Quiet with Unsettled spells and isolated Active intervals. Although an ongoing chance of further G1/Minor storms from any enhancement from CH57/+, greatest risk day 3 (26th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	40	20	30	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
21/1127	Partial	AR3169	NE	500	Missing behind on 24th	Small chance of glancing impact,

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Figure 2a: Enlil and ensemble showing missing CME, behind Earth. Also showing ongoing fast winds, with only a very weak enhancement on the 26th (day 3)

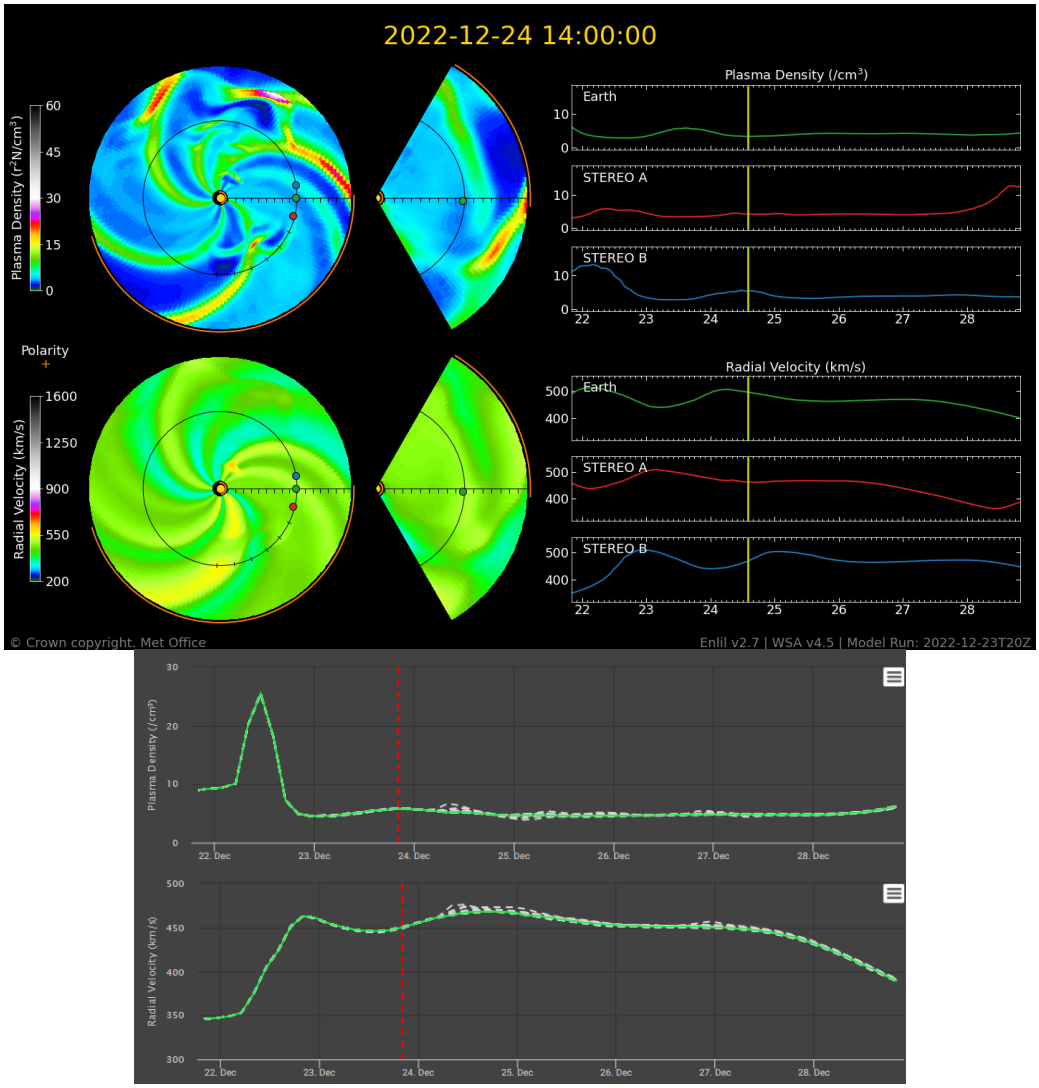
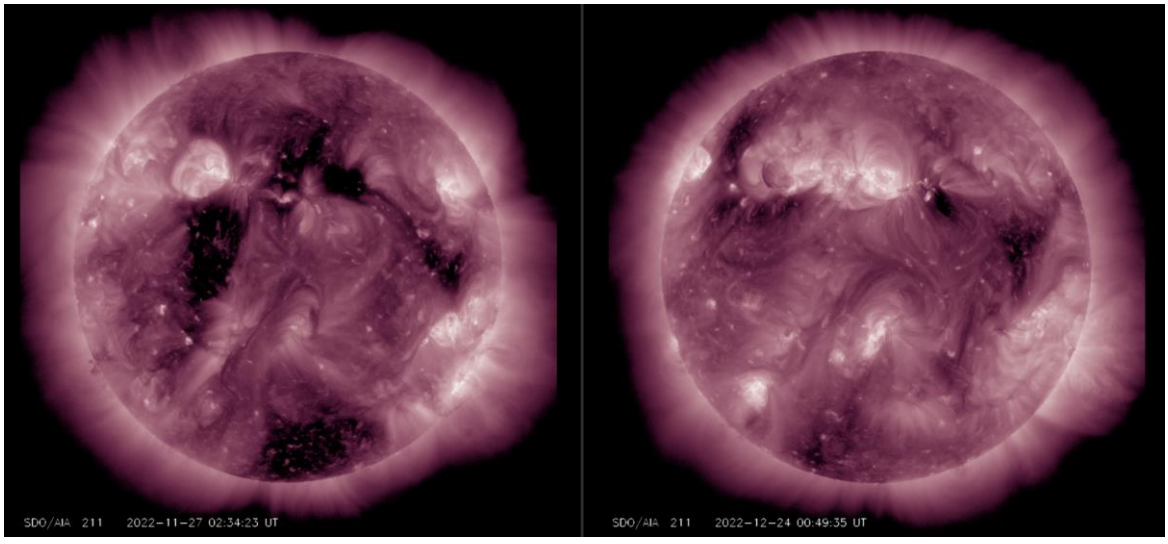


Figure 2b: SDO aia-211 showing previous (left) and current (right) rotation



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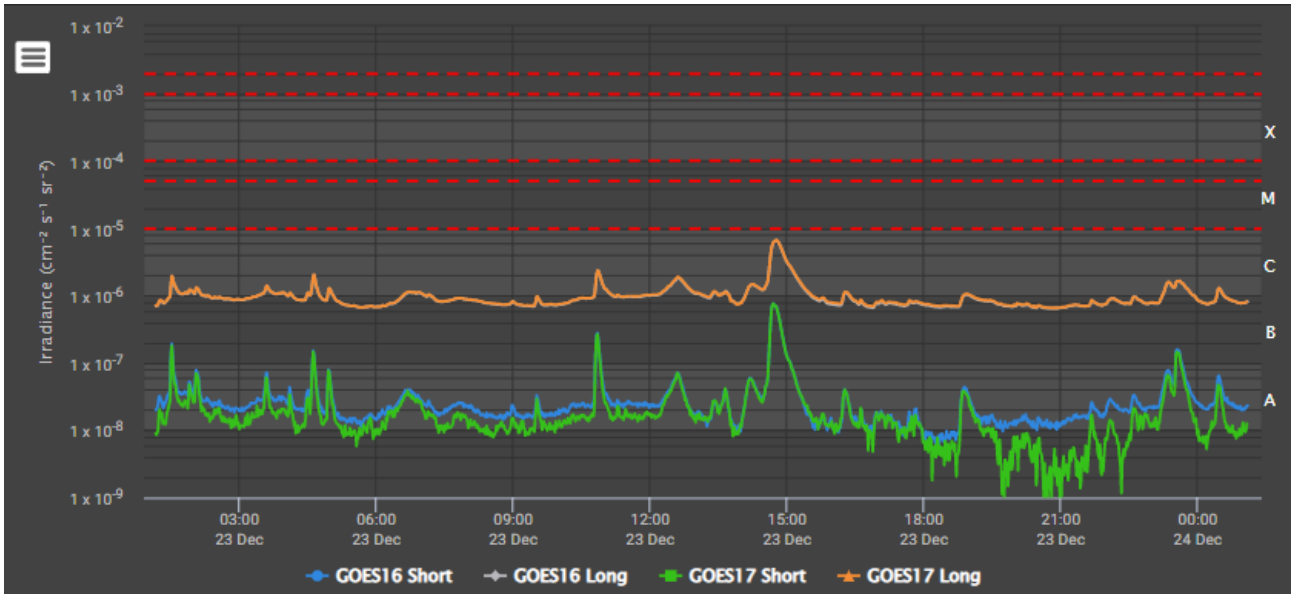
Radio Blackouts - X-Ray Flares:

Current Low activity is expected to continue with the current sunspots on the disc relatively stable, with only occasional C-class flares observed. There is a slight chance of M-flares.

Main regions of interest are AR3169 Cso/Beta and AR3171/Cao, which along with a region that recently decayed to no longer be visible (AR3174) form a long train of sunspots across the Suns north centre disc. Individual spots are difficult to attribute to each region, however current assessment has AR3169 comprising of the two lager positive leader spots connected to a region of evolving flux to the west which has ongoing flux emergence occurring, but only development of weak transient spots. AR3171 however, is a reverse polarity region (for the Sun's northern hemisphere for SC25) with a larger positive polarity trailer spot, and some small negative transient spots to its west. The other three sunspot regions are all smaller and simpler.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	10	10	10	10
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: GOES-16/17 X-ray Flux



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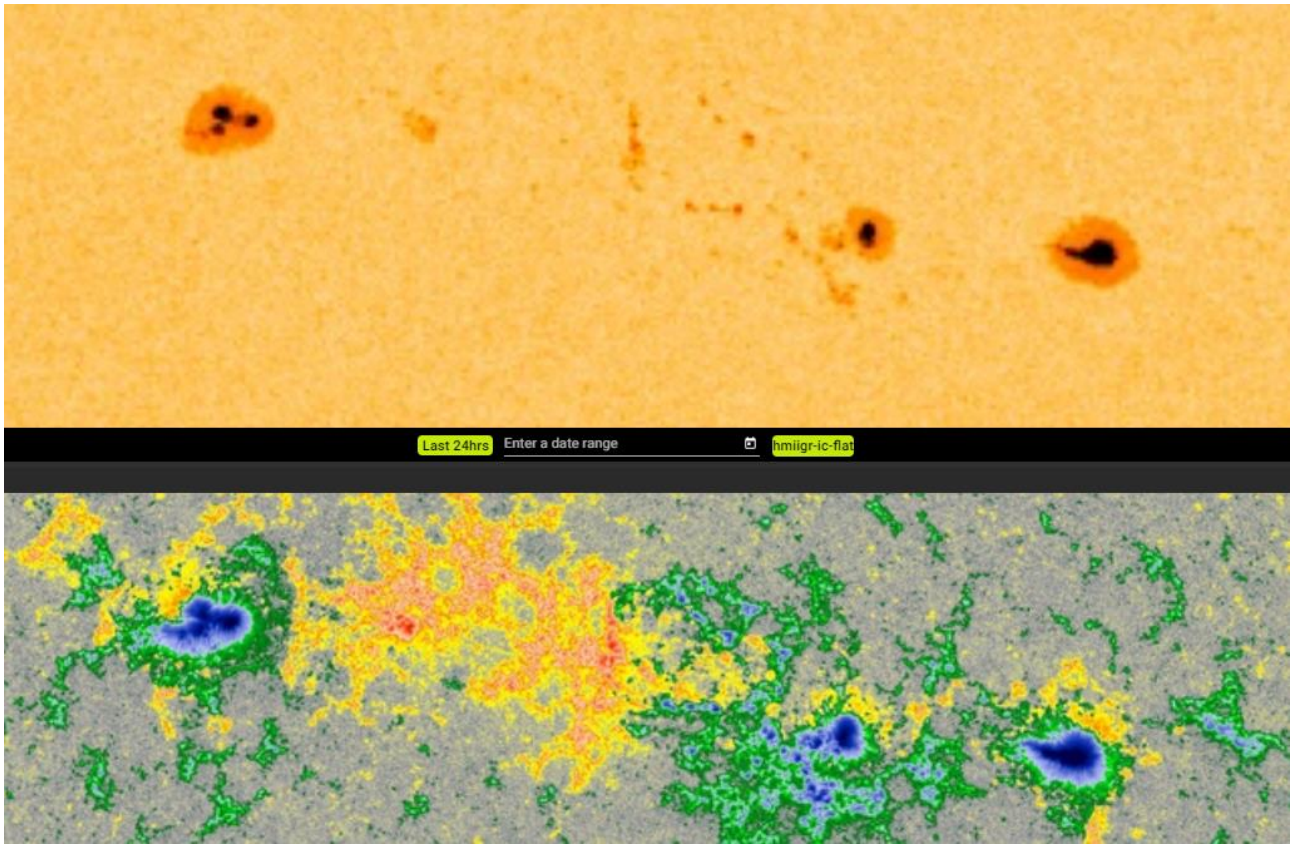
Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is expected to remain at background levels.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO hmi-intensitygram (top) and magnetogram (bottom) of AR3171 (left positive spot) and AR3169 (two right positive spots) Developing small spots in adjoining negative polarity area visible. (Yellow negative/blue positive)



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High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux as observed by GOES-16 is currently at background levels. A general, but erratic increase in observed flux is likely through the period due to a sequence of solar wind enhancements from the arrival of high speeds streams from the various coronal holes on the disc. Peak flux likely reaching High, perhaps day 2 (25th), but more likely later in the period, depending upon the timing and strength of any enhancement from CH57.

The associated 24 hour electron fluence is forecast to see a rising trend, with a chance of rising above the Active threshold by day 3 (26th). This rising trend is supported by persistence, however persistence is unlikely to be a reasonable guide from day 2 (25th) onward due to difference in coronal structure on this rotation. REFM is also indicating a general rising trend, but potentially too slowly.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	20	30	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 Electron flux (top) and fluence with REFM and persistence (bottom)

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